Examination of a Pressure Surge, Gravity Wave, and Atmospheric Internal Bore Associated with the 13 March 2003 Bow Echo

Rebecca Adams-Selin
Colorado State University

The 13 March 2003 bow echo initialized over central Oklahoma at 0200 UTC. The Oklahoma Mesonet is used to analyze the surface features associated with this bow echo system. Surface features usually associated with squall lines, the mesohigh and cold pool, are found to accompany this bow echo. Prior to new bowing development, the mesohigh surges ahead of the convective line while the cold pool remains centered behind it. Surface winds shift to a ground-relative outflow pattern upon arrival of the mesohigh surge. Approximately 30 min later, a new bowing segment forms with its apex slightly to the left (with respect to the direction of system motion) of the mesohigh surge. The cold pool follows the convective line as it bows.

Two wave-like features are identified with this system through spatial and temporal filtering. The first is a gravity wave, presumed to be generated by deep heating within the convective line, that moves at nearly 35 m s-1. The exact nature of the second wave-like feature cannot be determined from surface observations alone, although it appears related to the pressure surge feature described above. Passage of this feature in all mesonet stations affected by the system is marked by a sharp pressure rise and temperature drop.

An idealized simulation of this bow echo is run using the Cloud Model 1 (CM1) version 1.15. The 0000 UTC 13 March 2003 KOUN sounding is used to initialize the system. All of the observed surface features, including the mesohigh pressure surge and cold pool, are well-represented. A fast-moving gravity wave is generated by deep convective heating during the initialization of the system. The speed of this wave, approximately 33 m s-1, closely matches that of the first observed wave feature. A bore is also generated ahead of the convective system due to the cold pool impinging on a stable atmospheric layer. The stable layer is overtopped by an unstable layer where the mean environmental flow is close to the wave speed of the bore, allowing for trapping of the wave energy. Additional modifications are made to the simulation environment to simulate nighttime cooling. The effects of this cooling on the generated bore are explored.

A “real-data” simulation of the bow echo is also run using the Advanced Research Weather Research and Forecasting model (WRF-ARW) version 3.2. A fast-moving gravity wave is generated, but an atmospheric bore is not, nor is the pressure surge. Evaluation of the simulation environment shows that the stability structure is significantly different than that of the 0000 UTC KOUN sounding.